

Chapter 6: Vulnerability, Assessment, Climate Change Impacts and Adaptation Measures

Human activities have dramatically altered the world's climate, oceans, land, ice cover, and ecosystems, resulting in impacts on almost every sector, including human health, agriculture, infrastructure, and natural resources. In the United States, climate change has already resulted in more frequent heat waves, extreme precipitation, larger wildfires, and water scarcity. These are serious challenges that directly affect families, communities, and jobs across the nation and all over the world. The only way to prepare and respond effectively is with a sound understanding of the changes underway and the threats and opportunities they present over time (Karl et al. 2009).

Significant progress in understanding the impacts of climate change and potential responses has been made since the publication of the *U.S. Climate Action Report 2010* (2010 CAR) (U.S. DOS 2010), including major advances in the knowledge of Earth's past and present climate, improved capacity to project future conditions, and better understanding of vulnerabilities to the impacts of global change. The draft *Third National Climate Assessment* (NCA) Report, developed under the direction of the U.S. Global Change Research Program (USGCRP) and released for public comment in January 2013, contains expanded documentation of climate impacts and response activities across the United States. A significant change in the framing of this Third NCA Report is a focus on information that is useful for decision makers who are increasingly faced with managing climate-related risk. Unlike previous NCA reports, this report will be released electronically and will be fully searchable online, with links to the underlying data. Access will be facilitated through a number of innovative points of entry, including indicators of change and regional, sectoral, and intersectoral topics.

Like many other countries, the United States is increasingly vulnerable to current and projected climate changes; there is growing emphasis on adaptation and preparedness measures to increase the nation's resilience and take advantage of opportunities in the face of significant change (Karl et al. 2009). Efforts are now being made at multiple geographic scales to incorporate climate change into decisions at the national (including the U.S. government), state, regional, and local levels, such as resource managers and policy makers within the public and private sectors (ICCATF 2011). For example, in the fall of 2009, President Obama issued the ambitious *Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance* (EOP 2009), which has dramatically shifted the federal landscape of government stewardship toward sustainability and climate adaptation. In response, federal agencies completed their first set of agency-specific adaptation plans that were publicly released in February 2013.¹ These plans focus on identifying and addressing the impacts of climate change on each agency's operations, program, and missions.

In June 2013, the President provided further direction to government agencies on reducing emissions and enhancing preparedness for climate change in his *Climate Action Plan* (EOP 2013). Federal agencies have expanded their collaborative activities with multiple stakeholders both inside and outside of the federal government and are developing joint strategies that will address several cross-cutting issues. For example the first national strategies for incorporating climate change into ecosystem management (NFWPCAP 2012) and managing water supplies (ICCTF 2011) were released in 2013 and 2011, respectively. Reflecting the distributed nature of authority in the U.S. federal system as well as the need for adaptation decisions to be based on local assessments and needs, many state, local, and tribal governments have been leaders in conducting vulnerability assessments and planning and implementing adaptation activities. (Bierbaum et al. 2013). These efforts are being accomplished both individually and in partnership with the federal government, other states, localities, and tribes.

This chapter outlines, discusses, and provides examples of the following key topics:

- *Observations:* Recently observed changes in the climate and the associated impacts.

¹ Develop Agency Sustainability Plans. See <http://sustainability.performance.gov/>.

- *Vulnerabilities and Impacts:* Observed and projected climate and global change vulnerabilities and impacts in the United States (regional, sectoral, and cross-cutting).
- *Research and Assessments:* Ongoing and planned research to improve the understanding of impacts, vulnerabilities, and options for response.
- *Adaptation Actions:* Ongoing adaptation measures, including examples of adaptation actions taking place at multiple scales throughout the United States.

(1) OBSERVATIONS

Through a range of recent scientific observations, the evidence for a changing climate has strengthened considerably since the 2010 CAR. Over the past 50 years, stronger evidence coming from the scientific community indicates that human activities—primarily the burning of fossil fuels—have affected the climate in unprecedented ways. Most notably, average global temperature has increased over time. For example, U.S. average temperature has increased by about 1.5°F since 1900 (Karl et al. 2009). The most recent decade was the nation’s warmest on record (NOAA/NCDC 2012b). Other observations of changes in our global climate include the increase in extreme weather and climate events in recent decades (NOAA/NCDC 2012a). Over the past 50 years, much of the United States has seen an increase in prolonged stretches of excessively high temperatures, a greater number of heavy downpours, and in some regions more severe droughts. Heat-trapping gases already in the atmosphere have committed us to a hotter future with more climate-related impacts over the next few decades. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, now and in the future (Karl et al. 2009).

(2) VULNERABILITIES AND IMPACTS

There are many public and private efforts to analyze the vulnerabilities of regions and sectors of the United States to the impacts of climate change. The most comprehensive, and the only official national effort, is the quadrennial NCA, which analyzes climate observations, impacts, and response options across U.S. regions and multiple sectors (NCA 2013). The Third NCA Report and many other vulnerability assessments, such as those conducted at a smaller scale across the country by the U.S. Geological Survey, document growing evidence of climate change trends and demonstrate that, like many other countries, the United States is increasingly vulnerable to current and projected changes in its climate. However, while many effects of climate change are negative, there could be positive effects as well (Bierbaum et al. 2013), including the potential for increased agricultural productivity in northern parts of the country (Karl et al. 2009).

The upcoming Third NCA Report addresses climate impacts and vulnerabilities within some sectors individually, as well as climate-related risks and opportunities across and within those sectors. A common theme throughout these cross-sectoral components of the Third NCA Report is the connection across the sectors and the way changes in one sector are amplified or attenuated through connections with other sectors. Another theme considers how decisions can influence a cascade of events that affect individual and national vulnerability and/or resilience to climate changes across multiple sectors. This “systems approach” showcases how adaptation and mitigation activities are themselves dynamic and interrelated strategies that intersect with the sectors described in this chapter. These themes also address the importance of underlying vulnerabilities and the ways they may influence the risks associated with climate change.

Regional Considerations

Landscapes, ecosystems, communities, and economies vary dramatically across the United States, but also share many common attributes. Each region is affected by changes in the global and national economies; each adds to the complex and multifaceted U.S. culture; each is connected to the same integrated infrastructure, such as transportation, communications, and energy systems; and they are all affected by the changing climate (Karl et al. 2009).

TABLE 1.1: REGIONAL OBSERVATIONS OF CLIMATE CHANGE

1 This table provides key examples of regional observations of climate change impacts that are already occurring.

Region	Observations
Northeast	Heat waves, coastal flooding due to sea level rise and storm surge, and river flooding due to more extreme precipitation events are increasingly affecting communities in the region (Horton et al. 2011).
Southeast and the Caribbean	Decreased water availability, exacerbated by population growth and land-use change, is causing increased competition for water; risks associated with extreme events, such as hurricanes, are increasing (Karl et al. 2009, Kunkel et al. 2013a).
Midwest	Longer growing seasons and rising carbon dioxide (CO ₂) levels are increasing yields of some crops, although these benefits have already been offset in some instances by occurrence of extreme events, such as heat waves, droughts, and floods (Karl et al. 2009, Kunkel et al. 2013b).
Great Plains	Rising temperatures are leading to increased demand for water and energy and impacts on agricultural practices (Karl et al. 2009, Kunkel et al. 2013c).
Southwest	Drought and increased warming have fostered wildfires and increased competition for scarce water resources for people and ecosystems (Garfin et al. 2013).
Northwest	Changes in the timing of streamflow related to earlier snowmelt have already been observed and are reducing the supply of water in summer, causing far-reaching ecological and socioeconomic consequences (Karl et al. 2009, Kunkel et al. 2013d).
Alaska and the Arctic	Summer sea ice is receding rapidly, glaciers are shrinking, and permafrost is thawing, causing damage to infrastructure and major changes to ecosystems; impacts on Alaska native communities are increasing (Markon et al. 2012).
Hawaii and U.S. Affiliated Pacific Islands	Increasingly constrained freshwater supplies, coupled with rising temperatures, are stressing both people and ecosystems and decreasing food and water security (Keener et al. 2012).
Coastal Zone	Coastal lifelines, such as energy and water supply infrastructure and evacuation routes, are increasingly vulnerable to higher sea levels and storm surges, inland flooding, and other climate-related changes (Burkett and Davidson 2013).
Oceans	The oceans are currently absorbing about a quarter of human-caused CO ₂ emissions to the atmosphere and more than 90 percent of the heat associated with global warming, leading to ocean acidification and the alteration of marine ecosystems (Griffis and Howard 2012).

2 **Sectoral Considerations**

3 Every sector of the U.S. economy is affected in some way by changes in the climate, including changes in temperature,
 4 rising sea levels, and more extreme precipitation events and droughts. Such sectors as human health, water resources,
 5 agriculture, energy, and the natural environment are already experiencing the impacts of climate change at multiple scales
 6 (local, national, international) (Karl et al. 2009). However, none of these sectors exists in isolation; each connects directly
 7 and indirectly to other sectors.

8 ***Water***

9 The water cycle sets the stage for all life to exist and is a driver of climate-related change through changes in
 10 precipitation, runoff, and evaporation. Water supplies and water management are also strongly affected by changes in
 11 temperature and extreme events, such as droughts and floods. Some observed impacts of climate change on the water

cycle include intensified floods in some regions, summer droughts in much of the United States, and changes in seasonality of runoff (Karl et al. 2009). Water supplies are being reduced by climate change and are affecting ecosystems and livelihoods in many regions across the nation (e.g., the Southwest, the Great Plains, the Southeast, and the islands of the Caribbean and the Pacific, including the state of Hawaii).

With demand for water increasing, supplies of surface and groundwater are already stressed. Water shortages increase the competition for water among agricultural, energy, municipal, and environmental users. Many of the expected effects of climate change on the water cycle affect human safety and health, property, infrastructure, economy, and ecology in basins across the country. Additionally, water resources managers and planners in most regions will encounter new risks, vulnerabilities, and opportunities in water management where existing practices may not be enough to ensure the future sustainability and safety of communities and industry. (Karl et al. 2009).

Energy

The U.S. energy supply system is diverse and robust in its ability to provide a secure supply of energy with only occasional interruptions. However, current and projected impacts of climate change will shift seasonal patterns of energy use toward a reduction in heating demands and an increase in cooling requirements. Along with a variety of economic factors and an increase in extreme events in vulnerable areas, shifts in energy use and climate extremes pose risks to energy security. Extreme weather events and water shortages are already interrupting energy supply, and impacts are expected to increase in the future. Most vulnerabilities and risks to energy supply and use are created by local events, but the impacts often are national and international in scope (Wilbanks et al. 2012a, Zamuda et al. 2013).

Transportation

The U.S. economy depends on personal and freight mobility provided by the country's transportation system. Essential products and services, such as energy, food, manufactured goods, and fuel, all depend in interrelated ways on the reliable functioning of transportation systems. There is already substantial evidence of impacts to transportation systems associated with extreme events, such as severe storms with high winds, floods, droughts (affecting barge traffic), and heat waves (affecting rail systems and airports in particular), as well as coastal erosion. Disruptions to transportation systems related to climate change have already caused large economic as well as personal losses, and these impacts are expected to increase in response to a changing climate (Karl et al. 2009).



Figure 6-1. Rail buckling under extreme heat.
Photo courtesy of the U.S. Department of Transportation.



Figure 6-2. Flooding of Nashville MTA Property, May 2010.
Photo courtesy of Nashville MTA and the U.S. Department of Transportation.

Agriculture

The United States produces nearly \$300 billion per year in agricultural commodities, with roughly half of that coming from the production of livestock. The agriculture sector has experienced adverse impacts on crops and livestock from extreme events, and these impacts are expected to increase over the next century. Increased carbon dioxide (CO₂) concentrations do have a positive effect on some crops, but agricultural productivity is expected to decline over time in response to invasive pest species and plant disease, and an increase in extreme events, such as floods, droughts and heat waves. The locations where crops can most beneficially be grown are shifting northward. Climate change has the potential to affect the patterns and productivity of crop, livestock, and fishery systems at the local, national, and global scales (Walthall et al. 2012).

Forestry

Forests provide numerous benefits, including wood production, clean drinking water, wildlife habitat, and recreation—and also provide carbon “sinks” that remove atmospheric carbon. Forest health decline and an increase in forest disturbances are already observed and projected due to increases in the acreage burned by wildfire, the spread of insects and disease, drought, and extreme events projected as a result of climate change. At the same time, there is growing awareness that forests may play an expanded role in carbon management through storing carbon and providing resources for bioenergy production (Vose et al. 2012).

Ecosystems and Biodiversity

Climate variability and change affect the living world (including people) through direct impacts on natural ecosystems, such as impacts on biodiversity (e.g., increased risk of extinction of species at local, regional, and national scales) and the location of species (e.g., substantial range shifts of many species of wildlife, fish, and native plants). Ecosystems provide a variety of services that are valued by society, including recreation, clean water, food, and a variety of other valued commodities. Ecosystem disruptions driven by climate change have direct impacts on humans, including reduced water supply availability and quality, the loss of iconic species and landscapes, and the potential for extreme events to overcome the services that ecosystems, such as coastal wetlands and barrier islands, provide in buffering the effects of severe storms (Staudinger et al. 2012).

Health

Climate change threatens public safety and health in many ways, including impacts from increased extreme weather events and wildfire, decreased air quality, changes in prevalence of diseases transmitted by insects, increases in food prices, and limitations on water availability. As temperatures increase, risks of heat stress, respiratory stress from poor air quality, and the spread of waterborne diseases are increasing. Absent adaptation efforts, some existing health threats will intensify, and new health threats will emerge (IWGCCH 2010).

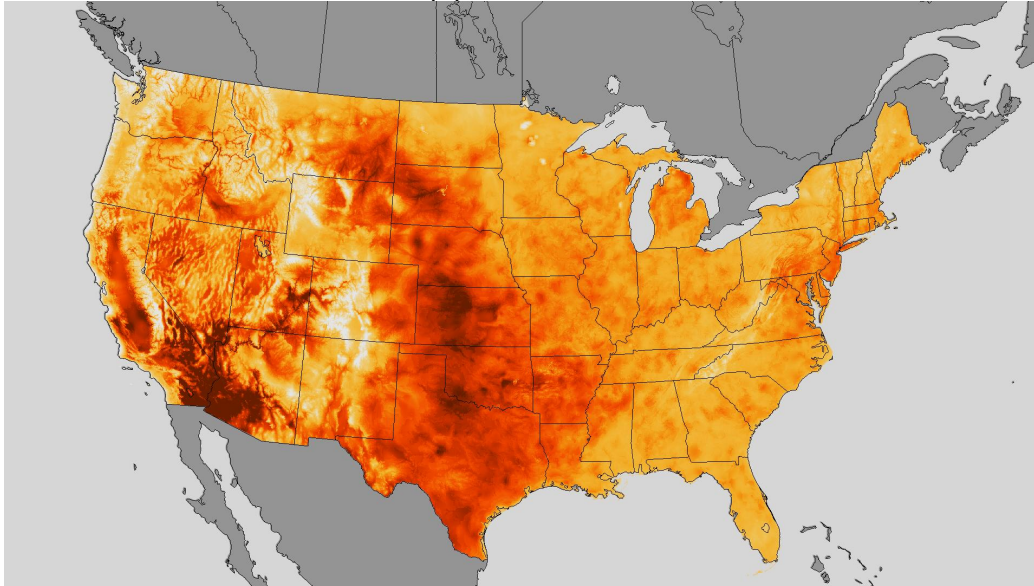


Figure 6-3. Heat Wave Sweeps Across the U.S. in July 2013.

Photo courtesy of the National Oceanic and Atmospheric Administration.



Figure 6-4. Human health impacts from extreme weather events.

Photo courtesy of NASA.

Cross-Sectoral Considerations (Linked Systems)

As noted above, climate change affects individual sectors in a variety of ways, but in managing risk and supporting adaptation decisions, it is also critical to consider cross-sectoral impacts and linkages between systems. For example, climate change affects sectors, such as water, energy, agriculture, health, and ecosystems, but also the intersections of these sectors. Some examples of recent research and observations on cross-sectoral considerations are summarized below.

Urban Infrastructure and Vulnerability

Climate change poses a series of interrelated challenges for the country's most densely populated places: its cities. Many U.S. cities depend on aging infrastructure, such as water and sewage systems, roads, bridges, and power plants, which are in need of repair or replacement. Climate-related impacts, such as rising sea levels, storm surges, heat waves, and extreme

weather events, have already compounded and will continue to compound these structural issues, stressing or even overwhelming these essential services.

In combination with the increase in coastal development, damage caused by storm surges and sea level rise is resulting in increased damage to critical infrastructure, such as roads, buildings, ports, wastewater treatment, and energy facilities. Extreme heat is another climate driver that damages transportation infrastructure, such as roads, rail lines, and airport runways (Wilbanks et al. 2012b). An example of the interdependence of infrastructure systems was observed in New York and New Jersey during Superstorm Sandy. The loss of electric power led to impacts on communications systems, which led to cascading effects in the transportation and public health sectors (Wilbanks et al. 2012b).

Land-Use and Land-Cover Change

Humans affect climate and are also vulnerable to climate impacts through land-use decisions (e.g., for land development, agriculture, or conservation of species). Adaptation options include managing vegetation to reduce heat in cities; managing landscapes to enhance environmental benefits, such as clean water supplies; restricting development in floodplains; and elevating homes to reduce vulnerability to sea level rise or flooding. Land-use and land-cover-related options for slowing the speed and intensity of climate change include expanding forests and conserving existing forest cover to pull more carbon from the atmosphere, designing cities to reduce energy use and motorized transportation demands, and altering agricultural management practices to increase carbon storage in soil (Loveland et al. 2012).

Tribal Culture, Lands, and Resources

The people, lands, and resources of indigenous communities across the United States face an array of climate change impacts and vulnerabilities that threaten many different Native communities' health, well-being, and ways of life. In parts of Alaska, Louisiana, the Pacific Islands, and other coastal locations, climate change impacts (through erosion and inundation) are so severe that some communities are already undergoing relocation from their historical homelands to which their traditions and cultural identities are tied.² Existing stresses on Native people's traditional food supplies, water quality and quantity, economic development, and health and safety are exacerbated by climate change (Maldonado et al. 2013, Doyle et al. 2013, Lynn et al. 2013).

Key vulnerabilities and drivers of impacts for Native communities include the loss of traditional knowledge, degradation of forests and ecosystems, lack of food security and traditional foods, water scarcity, arctic sea ice loss, permafrost thaw, and relocation from historic homelands (Hinzman et al. 2005, Dittmer 2013). In addition to the 566 federally recognized tribes and Alaska Natives, state-recognized and nonrecognized tribal groups share these vulnerabilities. Native populations are particularly vulnerable to the impacts of climate change because they depend very directly on the environment for their physical, mental, intellectual, social, and cultural well-being (Mahesh et al. 2013, Cochran et al. 2013).

Water, Energy, and Land

Energy, water, and land systems interact in many ways. Energy production requires varying amounts of water (primarily for cooling) and in some cases, substantial amounts of land; water projects require energy (for treatment and delivery) and land; and land uses often depend upon availability of energy and water. Climate change impacts each of these sectors directly, but the implications of climate change on the intersections between systems are often unrecognized. While there has been extensive study of water, energy, and land sectors individually, as well as the bilateral relationships between the sectors, there are few analyses of how multisectoral relationships are affected by a changing climate and how these relationships will influence technologies deployed in future energy systems, as well as options for reducing greenhouse

² State of Alaska Division of Community and Regional Affairs Planning and Land Management, cited 2012: Newtok Planning Group. See http://www.commerce.state.ak.us/dca/planning/npg/Newtok_Planning_Group.htm.

gas emissions. However, the availability of energy, water, and land resources and the ways the systems interact vary across U.S. regions. Consequently the impacts, related risks and opportunities related to climate change vary widely (Skaggs et al. 2012).

Coastal Zones

Approximately 164 million Americans—more than 50 percent of the population—now live in coastal and Great Lakes watershed counties and help generate 58 percent of the national gross domestic product. Coastal areas are already affected by violent storms and sea level rise, so both the lives and the livelihoods of large numbers of Americans are currently affected, with more impacts expected in the future. Coastal ecosystems are extremely vulnerable, in part because they have already been so altered by human activity; coastal wetlands are expected to suffer further losses of productivity and services that they provide to protect human settlements. Man-made components of coastal zones are also vulnerable to climate change, such as water supply lines, energy infrastructure, ports, tourism and fishing-based communities, and evacuation routes. As climate continues to change, repeated disruption of lives, infrastructure, and nationally and internationally important economic activities will pose challenges to populations living in coastal zones, and aggravate existing impacts on valuable and irreplaceable natural systems (Burkett and Davidson 2013).

(3) RESEARCH & ASSESSMENTS

As discussed above, global change is happening now and is well documented. The only way to reduce the risks and maximize the opportunities associated with these significant changes is to enhance preparedness through a sound understanding of the changes underway, the threats and opportunities they present, and how they will change over time.

The U.S. Congress recognized this urgent need by passing the Global Change Research Act of 1990³ (GCRA), which called for a federal interagency program to “assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.” The U.S. Global Change Research Program (USGCRP) has been working to fulfill that mandate for the last 22 years, and is now coordinating the federal government’s \$2.6 billion⁴ annual investment in global change research—one of the largest such investments in the world.

In addition to establishing the USGCRP, the GCRA mandates that the USGCRP develop a quadrennial report known as the *National Climate Assessment* (NCA). The NCA serves as a means to bring together the best peer-reviewed science on climate change and its impacts on the United States, leveraging research across sectors and providing a basis for future assessment and action. The current draft Third NCA Report was developed through an open and transparent process using a broad engagement strategy that included more than 1,000 direct contributors and 240 chapter authors drawn from government scientists, academia, resource management agencies, and nongovernmental organizations (NGOs) (Draft Third NCA Report, 2013). In addition, more than 80 external organizations from the public and private sectors are now part of the NCA network, which supports the NCA activities and helps to share its findings. The Third NCA Report, due to be released in final form in early 2014, is expected to become the authoritative source for information on the vulnerabilities and impacts of climate change in the United States.

In addition to this significant investment in global change research and the development of the NCA, many of the vulnerabilities discussed in the Impacts section above are being addressed across multiple levels of government and in the private sector through programs at a variety of geographic scales for specific purposes, including management of natural resources, long-term development planning, and infrastructure investment. A goal of the U.S. Interagency Climate Change Adaptation Task Force (Task Force), USGCRP, and federal agencies is to bring this work together to leverage synergies and strengths among these many and varied programs.

³ Global Change Research Act of 1990. See <http://globalchange.gov/about/global-change-research-act>.

⁴ U.S. Global Change Research Program. Budget. See <http://globalchange.gov/about/budget-documents>.

Sustained Assessment Process

A primary goal of the NCA is to help the nation anticipate, mitigate, and adapt to impacts from national and global climate change and climate variability. As the Third NCA synthesis report was being prepared, a vision for a “sustained assessment” process took shape (Draft Third NCA, 2013). This includes an ongoing process of scientific evaluation and adaptive learning, improving understanding of the nation’s vulnerabilities and its capacity to respond. Ongoing assessment activities, in addition to producing periodic synthesis reports as required by law, support the statutory requirements of the GCRA: to understand, predict, assess, and respond to rapid changes in the global environment. Continuous efforts to integrate new knowledge and experience can provide decision makers with more timely, concise, and useful information and permit extensive engagement with public and private partners. A well-designed and -executed sustained assessment process will also generate new insights about climate change, its impacts, and the effectiveness of societal responses. It can also help define the range of information needs of decision makers and end users relative to adaptation and mitigation, as well as the associated costs of impacts and benefits of response actions.

Indicators

Indicators are measurements or calculations that represent important features of the status, trends, or performance of a system (such as the economy, agriculture, natural ecosystems, or changes in Arctic sea ice cover). Indicators are used to identify and communicate changing conditions to inform both research and management decisions. Part of the vision for the sustained NCA process described above is a system of physical, ecological, and societal indicators that communicate key aspects of physical climate changes, climate impacts, vulnerabilities, and preparedness for the purpose of informing both decision makers and the public with scientifically valid information. Ideally, this system would be scalable for multiple geographic levels of use, would augment and expand on existing agency efforts when possible, and would include indicators to measure adaptive capacity or the effectiveness of adaptation actions (Janetos et al. 2013).

A robust public/private working group is currently dedicated to developing such indicators, which are expected to include both *current* indicators (indicators that describe what is happening now and in the past) and *leading* indicators (indicators representing potential future states of the system). Most of these indicators focus on the United States, but some include global trends to provide context or a basis for comparison.

Scenarios and Regional Climate Information

Scenarios used for the draft Third NCA report included information on global and regional climate, sea level rise, and land use/socioeconomic conditions (Draft Third NCA Report, 2013). Major new reports were developed for each of the eight regions of the United States, documenting historic climate trends, as well as producing standardized projections under the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios A2 and B1 (relatively high end and low end emissions scenarios, respectively) (Nakićenović et al. 2000). In addition, an interagency report was developed on the current state of knowledge of global sea level rise, including four potential scenarios for the year 2100 resulting from climate-related processes, such as thermal expansion of the oceans, melting of ice sheets, and other factors. These scenarios were provided to NCA authors to assist in helping them build internally consistent views of future impacts across sectors and regions.⁵

Transparency and Review

The Third NCA Report process has made major strides toward maximizing transparency of data and sources that underlie the key conclusions (Draft Third NCA Report, 2013). It is one of the first major U.S. government reports that will be delivered electronically, facilitating access via Internet links to all of the underlying data and publications. The findings

⁵ National Climate Assessment and Development Advisory Committee. Scenarios for Climate Assessment and Adaptation. January 9, 2013. See <http://scenarios.globalchange.gov/content/scenarios>.

will provide a foundation for a new comprehensive Web-based system for providing shared data and analytic capabilities, known as the Global Change Information System, currently being developed. In addition, “traceable accounts” have been developed for all of the key findings in the chapters. These accounts document the authors’ process for coming to their conclusions, including an itemization of remaining uncertainties.

Engagement and Communications

Partnerships, two-way communication, and ongoing and meaningful engagement are critical to promoting understanding of and action toward addressing climate change. The USGCRP’s 2012 Strategic Plan and the five National Research Council (NRC) *America’s Climate Choices* reports underscore the importance of engagement and communications to informing decisions and achieving meaningful action (USGCRP 2012, NAS/NRC 2011). Partnerships and engagement strategies among federal and nonfederal participants are needed to (1) communicate effectively about climate vulnerabilities, impacts, risks, and opportunities; (2) enhance the relevance of actionable information; (3) encourage capacity building; (4) create opportunities for meaningful engagement of end users and public and private decision makers to inform the substance of the assessment; and (5) offer opportunities for input, evaluation, review, and feedback. To this end, an important component of the NCA is NCAnet: the “network of networks” mentioned above, that will help to build the content of the assessment and communicate the NCA process and products to a broader audience.

(4) ADAPTATION ACTIONS

All levels of the U.S. government have increased efforts to plan for and implement climate adaptation (to address and prepare for impacts) and mitigation (to reduce emissions) over the last decade. In the past four years, the United States has made major strides toward increasing climate preparedness and resilience, initially through implementation of Executive Order (E.O.) 13514 and the Interagency Climate Change Adaptation Task Force, followed by President Obama’s June 2013 *Climate Action Plan*⁶ (EOP 2013). Given the federal system of government and the need for decision and action at the local level, adaptation, resilience, and preparedness activities necessarily take place at all levels of government and across the public and private sectors.

The Federal government itself has made substantial progress in incorporating adaptation activities across the country, though they are not widely known or recognized by the public. Several of the most significant efforts are documented in the following section. In many cases, even more significant progress has been made within U.S. regions, states, and cities, with cities in particular making major strides toward resilience and sustainability goals. Even with this progress, however, the nation must do more to avoid or adapt to serious impacts of climate change that have large social, environmental, and economic consequences.

Sample U.S. Adaptation Activities at Multiple Levels

The sample sector- and region-specific impact summaries and adaptation projects included in this section demonstrate the variety and scale of adaptation efforts in progress within the United States. The examples are illustrative and are not a comprehensive listing of all efforts across the nation.

Federal Government Action

In spring of 2009, the Obama Administration convened the Interagency Climate Change Adaptation Task Force (Task Force), co-chaired by the White House Council on Environmental Quality (CEQ), the White House Office of Science and Technology Policy, and the National Oceanic and Atmospheric Administration (NOAA), and including representatives from more than 20 federal agencies. In October 2009, President Obama signed E.O. 13514, *Federal Leadership in Environmental, Energy, and Economic Performance* (EOP 2009). E.O. 13514 directed federal agencies to reduce

greenhouse gas pollution, eliminate waste, improve energy and water performance, and leverage federal purchasing power to support clean energy technologies and environmentally responsible products. In addition, it required all federal agencies to assess their vulnerabilities to the impacts of climate change and directed the Task Force to develop a report with recommendations for how the federal government could strengthen policies and programs to better prepare the nation to adapt to a changing climate.

In its October 2010 Progress Report to the President, the Task Force articulated a set of policy goals and recommendations that called for collaborative approaches within the federal government to address key cross-cutting issues related to climate change adaptation (ICCATF 2010). Specifically, the Task Force recommended that the federal government:

- **Encourage and mainstream adaptation planning across the federal government**, including through adaptation planning within federal agencies.
- **Improve integration of science into decision making**, including through prioritizing activities that address science gaps important to adaptation decisions, building science translation capacity to improve the communication and application of science to meet the needs of decision makers, and developing an online data and information clearinghouse for adaptation.
- **Improve water resource management in a changing climate** through strengthening data and information systems for understanding climate change impacts on water, developing a national action plan to strengthen climate change adaptation for freshwater resources.
- **Protect human health by addressing climate change in public health activities**, including through enhancing the ability of federal decision makers to incorporate health considerations into adaptation planning and building integrated public health surveillance and early-warning systems to improve detection of health risks from climate change.
- **Facilitate the incorporation of climate change risks into insurance mechanisms**, including through exploration of a public/private partnership to produce an open-source risk assessment model.
- **Develop a strategic action plan focused on strengthening the resilience of coastal, ocean, and Great Lakes communities and ecosystems to climate change.**
- **Develop a strategy for reducing the impacts of climate change on the Nation's fish, wildlife, and plant resources and their habitats.**
- **Enhance efforts to support international adaptation**, for example, by developing a government-wide strategy to support multilateral and bilateral adaptation activities and integrate adaptation into relevant U.S. foreign assistance programs.
- **Coordinate capabilities of the federal government to support adaptation at all levels**, including through partnerships addressing local, state, and tribal needs.

In October 2011, the Task Force released a second Progress Report that outlined the federal government's progress in expanding and strengthening the nation's capacity to better understand, prepare for, and respond to extreme events and other climate change impacts (ICCATF 2011). The 2011 report also provided an update on actions in key areas of federal adaptation efforts, including building resilience in communities; safeguarding critical natural resources, such as freshwater; and providing accessible climate information and tools to help decision makers manage climate risks. The next such report is anticipated in 2014.

The President's Climate Action Plan

In June 2013, the Obama Administration released the nation's first comprehensive *Climate Action Plan* (EOP 2013). The plan outlines actions the federal government will take to cut carbon pollution, prepare the United States for the impacts of climate change, and work with the international community to significantly reduce emissions and forge a truly global solution to this global challenge. The plan acknowledges that even as the nation takes steps to cut carbon pollution, it must also prepare for the impacts of a changing climate that are already being felt across the country. Building on progress noted above, the plan:

- Directs federal agencies to support local climate-resilient investment by removing barriers or counterproductive policies and modernizing programs; and establishes a short-term task force of state, local, and tribal officials to advise on key actions the federal government can take to help strengthen communities on the ground.
- Pilots innovative strategies in the Hurricane Sandy-affected northeastern region to strengthen communities against future extreme weather and other climate impacts. For example, building on a new, consistent flood risk reduction standard established for the Sandy-affected region, agencies will update flood-risk reduction standards for all federally funded projects.
- Launches an effort to create sustainable and resilient hospitals in the face of climate change through a public-private partnership with the healthcare industry.
- Maintains agricultural productivity by delivering tailored, science-based knowledge to farmers, ranchers, and landowners; and helps communities prepare for drought and wildfire by launching a National Drought Resilience Partnership and by expanding and prioritizing forest and rangeland restoration efforts to make areas less vulnerable to catastrophic fire.
- Commits to the development of actionable climate science; the production of the NCA report and vulnerability assessments within economic sectors (including energy, health, transportation, food supply, oceans, and coastal communities); and the development of climate preparedness tools and information needed by state, local, and private-sector leaders through a centralized "toolkit" and a new Climate Data Initiative.

National Cross-Cutting Strategies

At the recommendation of the Task Force, as well as through other mechanisms, such as the National Ocean Council, congressional direction, and recommendations of external groups, such as the NRC, beginning in 2009, federal agencies prioritized an initial set of issues for consideration and developed a series of cross-cutting strategies to reduce the impacts of climate change on the nation's natural resources. The first of these, the October 2011 *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate*, was developed by federal agencies working with stakeholders to plan for adequate water supplies in a changing climate, while protecting water quality, human health, property, and aquatic ecosystems (ICCTF 2011). Federal agencies also partnered with state and tribal representatives to develop a *National Fish, Wildlife and Plants Climate Adaptation Strategy* to address the impacts climate change is having on U.S. natural resources and the people and economies that depend on them (NFWPCAP 2012); the final strategy was released in March 2013. In addition, as part of President Obama's *National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes* (EOP 2010), in April 2013 the National Ocean Council released the final *National Ocean Policy Implementation Plan* (NOC 2013), which includes a series of actions to address "Resiliency and Adaptation to Climate Change and Ocean Acidification," one of nine priority objectives identified by the National Ocean Policy.

Agency Adaptation Plans

In response to the directive given to federal agencies in E.O. 13514 (EOP 2009), in March 2011, CEQ issued guidance on how agencies should integrate climate change adaptation into their planning, operations, policies, and programs (EOP/CEQ 2011). In response, Agency Adaptation Plans were submitted to CEQ as part of an annual sustainability planning process in June 2012 and were released for public review in February 2013. These plans integrate adaptation planning into the operations, policies, and programs of all federal agencies. For example:

- The U.S. Department of Transportation's (DOT) plan describes how increased flooding would affect the transportation sector and notes that the Federal Highway Administration will develop guidance for incorporating climate change considerations into the planning and design of projects in coastal areas. DOT has explicitly authorized use of its state transportation funds for adaptation activities (U.S. DOT 2013).
- The U.S. Department of Homeland Security (DHS) is working to ensure the nation's resilience to more frequent or extreme natural disasters, including the need to ensure safety and stability in the Arctic,⁷ and prepare for changing conditions along the nation's borders (U.S. DHS 2012).⁸ DHS has developed planning scenarios that include consideration of a series of cascading impacts associated with increased intensity of hurricanes and a nearly ice-free Arctic in the summer with thinner ice cover in winter.
- The U.S. Environmental Protection Agency (EPA) identified potential climate-related risks to air quality and the availability and quality of water resources as critical topics. EPA is currently conducting regional assessments to identify areas of greatest priority, including identifying the most vulnerable populations and developing plans to address these priorities (U.S. EPA 2012).

These plans are meant to be living documents. Federal agencies will update them regularly, and the federal government will also be working to bring agencies together to address many of the common challenges that the plans identified. These include the need to provide better, more locally relevant information on climate change impacts; the need to ensure coordination of federal action to support adaptation efforts at the local level; the need to better integrate climate considerations into planning and investment decisions to ensure they are viable over the long term; and the need to protect federal facilities and personnel from extreme events and other impacts. These interactions will be facilitated by a new "community of practice" developed across federal agencies to address adaptation-related issues. This community includes individuals from more than 55 agencies and subagencies who are responsible for adaptation planning, demonstrating that more federal employees are now integrating climate adaptation planning into their day-to-day activities. The community shares best practices and is building a "knowledge network" to support adaptation activities.

Selected Examples of Interagency and Agency-Specific National Adaptation-Related Initiatives

*The National Integrated Drought Information System (NIDIS):*⁹ In 2006, NIDIS was established by Congress to help support a more proactive response to drought. The Web-based U.S. Drought Portal provides public access to NIDIS, which includes decision support tools like the Drought Early Warning System.¹⁰ The NIDIS implementation team also conducts workshops and meetings at the federal, state, and local levels to facilitate and inform stakeholders. NIDIS is made possible by the collaboration of 16 different federal agencies, as well as state, tribal, and local partners.

Coordinating Disaster Response: The Federal Emergency Management Agency (FEMA) has found that every dollar it spends on hazard mitigation provides the nation with about four dollars in future benefits (U.S. DHS/FEMA, MMC 2005 2011). FEMA, the U.S. Army Corps of Engineers (USACE), and state agencies are helping to address flood risks through

⁷ The waters of the Arctic are gradually opening up, not only to new resource development, but also to new shipping routes that may reshape the global transport system and affect U.S. national security interests. While these developments offer opportunities for growth, they are potential sources of competition and conflict for access and natural resources.

⁹ See <http://www.drought.gov/drought/>.

¹⁰ See: <http://www.drought.gov/drought/content/regional-programs/regional-drought-early-warning-system>.

the Silver Jackets program,¹¹ which creates interagency teams to simplify access to critical flood risk mitigation and planning resources. It also provides communities with a single point of contact to the federal government on these issues.

Incorporating Adaptation into Disaster Recovery during Superstorm Sandy: Recognizing the need to better publicize existing datasets and the development of climate-related decision support tools, the federal government introduced a suite of future flood risk tools to ensure that investments minimize risk to the greatest degree possible. FEMA, CEQ, USGCRP, the National Oceanic and Atmospheric Administration (NOAA), and USACE came together to combine various datasets and sources of expertise to produce tools accessible to local decision makers. See Box 6-1 for more information on the Hurricane Sandy Rebuilding Task Force.

Preventing Wildfire: In response to requirements of the Federal Land Assistance, Management, and Enhancement Act of 2009, the Wildland Fire Leadership Council directed the development of the National Cohesive Wildland Fire Management Strategy. The Cohesive Strategy is a collaborative process with active involvement from all levels of government and NGOs, as well as the public, to seek national, all-lands solutions to wildland fire management issues.

Addressing Sea Level Rise: The U.S. Geological Survey, National Park Service (NPS), U.S. Fish and Wildlife Service (FWS), and private and nonprofit partner organizations have been engaged in a research project aimed at assessing the vulnerability of Assateague National Seashore to sea level rise and increased erosion along the North Atlantic seaboard and identifying adaptation actions to ensure that the resources of the seashore remain resilient. Findings will be used to inform a coast-wide assessment of threats from sea level rise and related habitat conservation recommendations.

Conserving Biodiversity: The Bureau of Land Management (BLM), the U.S. Forest Service (USFS), and Colorado State University are currently assessing and inventorying limber pines in Wyoming, Montana, and Colorado, to evaluate stand structure and the extent of mountain pine beetle and white pine blister rust infestations. Also, BLM, USFS, NPS, FWS, the Bureau of Indian Affairs, states, universities, and several nonprofit partners have conducted the first-ever range-wide genetics survey of ponderosa pine. These research studies will increase understanding of the ability of these species to adapt to climate change and to identify genetically unique populations as priorities for conservation.

¹¹ See <http://www.nfrmp.us/state/>.

1 *Building Understanding of Climate Change*

2 *Impacts:* One example of Federal efforts in this
 3 area is NOAA’s Regional Integrated Science and
 4 Assessments (RISA) program,¹² which supports
 5 research teams that help expand and build the
 6 nation’s capacity to prepare for and adapt to climate
 7 variability and change. RISA teams work with
 8 public and private user communities to advance
 9 understanding; develop knowledge on impacts,
 10 vulnerabilities, and response options; develop
 11 products and tools to enhance use of science in
 12 decision making; and test governance structures for
 13 managing scientific research. In addition, NOAA’s
 14 Coastal Services Center¹³ provides technology,
 15 information, and management strategies for local,
 16 state, and national organizations to address
 17 challenges associated with flooding, hurricanes, sea
 18 level rise, and other coastal hazards.

19
 20 *Protecting Human Health:* The U.S. Department of
 21 Health and Human Services’ Centers for Disease
 22 Control and Prevention’s (CDC’s) Climate and
 23 Health Program developed the Climate-Ready
 24 States and Cities Initiative¹⁴ to help state and city
 25 health departments plan and prepare for the
 26 potential health effects of climate change. The
 27 initiative is currently working with eight states and
 28 two cities to assess, plan, and implement health-
 29 related climate change adaptation programs.
 30 Strategy development relies on the Building
 31 Resilience Against Climate Effects (BRACE)
 32 framework, a five-step sequential process for
 33 developing successful human health-related climate
 34 change adaptation. The framework includes
 35 vulnerability assessment, projection of disease
 36 burden, identification of adaptation options,
 37 implementation, and evaluation.

38
 39 *Managing Natural Resources:* The U.S. Department of the Interior (DOI) is developing information and tools to manage
 40 U.S. natural resources and support state and local efforts to prepare for climate change. Its WaterSMART¹⁵ program
 41 provides support to help states deal with rapid population growth, climate change, aging infrastructure, and land-use
 42 changes. BLM is currently conducting 15 Rapid Ecoregional Assessments¹⁶ across the U.S. West and Alaska to promote
 43 cross-boundary collaboration and informed decision making, and to facilitate collaborative development and prioritization
 44 of regional conservation, restoration, and climate adaptation strategies and actions. Additionally, the Bureau of

Box 6-1: Hurricane Sandy Rebuilding Task Force

Hurricane Sandy hit the U.S. Northeast in late October 2012. Sandy was the deadliest hurricane of the season, and the second-costliest hurricane in U.S. history. Many links have been made between Hurricane Sandy and climate-related global changes, such as warming oceans, greater atmospheric moisture, and sea level rise.

In December 2012, President Obama signed an Executive Order creating the Hurricane Sandy Rebuilding Task Force to “ensure that the Federal Government continues to provide appropriate resources to support affected State, local, and tribal communities to improve the region’s resilience, health, and prosperity by building for the future,” including in the face of climate change. The Task Force builds on lessons learned during previous disasters, where experience has shown that planning for long-term rebuilding must begin, even as the response is ongoing.

Working within the National Disaster Recovery Framework, the Sandy Task Force partnered with federal, state, and local officials as well as the private sector and nonprofit, community, and philanthropic organizations to promote recovery in a unified and coordinated manner and to incorporate adaptation principles. The Sandy Task Force also provided decision makers with information on potential impacts of climate change in the region, in formats or products that are as useful as possible, so that they can recover and rebuild in a way that increases resilience to future weather events.

¹² See <http://cpo.noaa.gov/ClimatePrograms/ClimateandSocietalInteractions/RISAProgram/AboutRISA.aspx>.

¹³ See <http://www.csc.noaa.gov/>.

¹⁴ See http://www.cdc.gov/climateandhealth/climate_ready.htm.

¹⁵ See <http://www.doi.gov/watersmart/html/index.php>.

¹⁶ See http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.html.

Reclamation recently completed a study defining current and future imbalances in water supply and demand in the Colorado River Basin and adjacent areas (U.S. DOI/BR 2012).

Supporting the Agricultural Sector: The U.S. Department of Agriculture (USDA) has integrated climate change objectives into its strategic plans and is expanding its focus on climate-related research and delivery capacity across its agencies to provide climate services to rural and agricultural stakeholders through existing programs, including the Cooperative Extension Service, the Natural Resources Conservation Districts, and the USFS' Climate Change Resource Center (USDA 2010). In June 2013, USDA also announced the development of climate science "hubs" that will facilitate access to climate-related scientific support for the agriculture sector.¹⁷ In addition, USDA is working with farmers in the Environmental Quality Incentives Program to improve water-use efficiency through measures that allow farmers to grow more crops with less water.¹⁸ The USDA *Climate Change Science Plan*, developed by an interagency USDA team, provides farmers, ranchers, foresters, landowners, resource managers, policy makers, and federal agencies with science-based knowledge to manage the risks, challenges, and opportunities of climate change and position themselves for the future (USDA/GCTF 2010).

Building a More Resilient Transportation Sector: To better understand potential climate change impacts on transportation infrastructure and identify adaptation strategies, DOT is conducting a comprehensive study of climate change impacts in the Mobile Bay region,¹⁹ with the intention of developing methods and tools that can be used nationwide. In addition, the Federal Transit Administration (FTA) is providing public transportation officials across the country with information on transit use during emergency response and on building the resilience of public transportation assets and services to weather and climate risks. FTA has also established a new Emergency Relief Program²⁰ that incentivizes incorporating actions to build climate resilience in disaster recovery efforts. The Federal Aviation Administration is analyzing aviation facility, service, and equipment profile data for vulnerability to a combination of potential storm surge impacts caused by climate change (U.S. DOT 2013).

Preparing for Future Energy Needs: The U.S. Department of Energy (DOE) recently conducted an assessment of climate change impacts on the U.S. energy sector and opportunities to make the energy system more resilient to climate-related risks (Zamuda et al. 2013). DOE is also contributing to enhanced climate preparedness and resilience by facilitating basic scientific discovery; enhancing research, development, demonstration, and deployment of more climate-resilient energy technologies; convening and partnering with stakeholders, including industry and federal, state, and local leaders; and providing technical information and assistance. These efforts include research and development programs to reduce the energy and water intensity of electricity generation and use, and transportation fuels production; to expand and modernize the electric grid; and to enhance energy efficiency and reduce energy demand for buildings, appliances, and vehicles.

In addition, DOE is developing information and tools that will help local and regional planners anticipate climate change effects on the energy system and adaptation needs. DOE is providing technical assistance and guidance for state and local energy assurance planning, as well as support and assistance to help communities prepare for climate impacts and to address challenges, such as simultaneous restoration of electricity and fuels supply. Many of these programs will have co-benefits of both increasing climate preparedness and resilience and reducing carbon pollution to slow the effects of climate change.

Developing Tools for Local Decisions: EPA is supporting local decision makers through a variety of programs and online tools, including the Climate Ready Estuaries (CRE) program²¹ and the Climate Ready Water Utilities Working Group.²² EPA's CRE program has supported more than 30 coastal adaptation projects in collaboration with 19 National Estuary

¹⁷ See http://www.usda.gov/oce/climate_change/regional_hubs.htm.

¹⁸ See http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/financial/equip/?cid=nrcs143_008334.

¹⁹ See http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/.

²⁰ See http://www.fta.dot.gov/map21_15025.html.

²¹ See <http://www.epa.gov/CRE/>.

²² See <http://water.epa.gov/infrastructure/watersecurity/climate/>.

Programs from Charlotte Harbor, Florida, to Puget Sound, Washington. EPA's Water/Wastewater Agency Response Network²³ helps water utility managers respond to and recover from emergencies that affect water system integrity and can lead to health risks from sewer system failures. Furthermore, These projects have used the best available science for the development of climate change vulnerability assessments and have developed ecosystem-based adaptation strategies. Finally, EPA has developed a National Stormwater Calculator, a desktop application that estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States (including Puerto Rico). Estimates are based on local soil conditions, land cover, and historic rainfall records, and the calculator accesses several national databases that provide soil, topography, rainfall, and evaporation information for the chosen site.²⁴

The USFS is creating similar decision-support tools for natural resource managers. The Template for Assessing Climate Change Impacts and Management Options generates reports capturing and organizing information for specific locations and natural resource issues by synchronizing climate change literature with mapping tools and climate models. Another tool, ForWarn, is a satellite-based forest disturbance monitoring system for assessing change. It offers tools to attribute forest changes to insects, disease, wildfire, storms, human development, or unusual weather. Archived data allow ForWarn users to track, compare, and monitor forest disturbances that have occurred across the conterminous United States since 2000. Finally, iTree is a software suite for urban and community forestry monitoring, analysis, and benefits assessment. iTree quantifies urban forest structure, environmental effects, and values.

Supporting Community-Level Resilience: The U.S. Department of Housing and Urban Development's (HUD's) Office of Policy Development and Research is helping to develop a toolkit of HUD initiatives that will provide new resources to communities to address the challenges resulting from climate change and growth patterns at the local level. In addition, HUD Sustainable Communities Regional Planning Grants encourage grant recipients to integrate climate adaptation into their regional housing, land use, and transportation planning.²⁵ The Regional Plan Association (RPA) of New York City is one of a number of HUD grantees incorporating climate information to enhance resilience of critical infrastructure to severe storms and coastal flooding. The RPA will also assess urban design implications of flood protection standards to develop new example standards, codes, and regulations for municipalities that will better equip them to adapt to extreme climate conditions.

Protecting Government Facilities: The National Aeronautics and Space Administration (NASA) has created an integrated effort between its Earth Science Division and Office of Infrastructure to look at the long-term effects of climate change for its facilities, many of which are in climate-sensitive areas, and to enable more informed future planning for its facilities and resource management.²⁶ In addition, through the Prediction of Worldwide Energy Resource project and Web portal, NASA provides user-friendly weather and solar data that help the energy, building, and agricultural industries plan for climate impacts.²⁷

Designing Infrastructure for the Future: In 2011, USACE issued new guidance on how its projects, systems, and programs can respond to future changes in sea level (USACE 2011). In the long term, USACE will use this information to incorporate climate change considerations into existing and new civil works infrastructure and ecosystem restoration projects in coastal areas to improve safety and resilience.

Regional, State, Local, and Tribal Adaptation Initiatives

The federal government recognizes that state and local action is essential to ensuring that the nation is prepared for the impacts of climate change. Across the country, communities are taking steps to protect themselves and invest in lasting, resilient infrastructure. The President has directed federal agencies to take action to support these communities, including

²³ See <http://www.awwa.org/resources-tools/water-knowledge/emergency-preparedness/water-wastewater-agency-response-network.aspx>.

²⁴ See <http://www.epa.gov/nrmrl/wswrd/wq/models/swc/>.

²⁵ See http://portal.hud.gov/hudportal/HUD?src=/program_offices/sustainable_housing_communities/sustainable_communities_regional_planning_grants.

²⁶ See <https://c3.nasa.gov/nex/projects/?tag=CASI%20-%20Climate%20Adaptation%20Science%20Investigators>.

²⁷ See <http://power.larc.nasa.gov/>.

forging new partnerships with states and local governments to improve the preparedness and resilience of cities and towns and to ensure that taxpayer dollars are used efficiently to promote stronger, safer communities. Tables 6-1 and 6-2 highlight selected examples of state, regional, local, and tribal adaptation efforts, which are in many cases accomplished with federal support or in coordination with multiple federal agencies.

TABLE 6-1: EXAMPLES OF STATE-LEVEL ADAPTATION ACTIVITIES

State	Adaptation Action
Alaska	The Alaska Climate Change Impact Mitigation Program provides funds for hazard impact assessments to evaluate climate change-related impacts, such as coastal erosion and thawing permafrost. ²⁸
California	California is implementing building standards mandating energy and water efficiency savings, advancing both adaptation and mitigation. The State Adaptation Plan calls for a 20 percent reduction in per-capita water use. ²⁹
Florida	Florida legislators have passed a law supporting low-water-use landscaping techniques and have established state zoning statutes that allow regional authorities to establish adaptation zones in preparation for sea level rise in projected impact areas. ³⁰
Hawaii	Hawaii has adopted a water code that calls for integrated management, preservation, and enhancement of natural systems (Keener et al. 2012).
Kentucky	The <i>Action Plan to Respond to Climate Change in Kentucky: A Strategy of Resilience</i> identifies six goals to protect ecosystems and species in a changing climate (KDFWR 2010).
Louisiana	The 2012 <i>Comprehensive Master Plan for a Sustainable Coast</i> includes both protection and restoration activities addressing land loss from sea level rise, subsidence, and other factors over the next 50 years (CPRAL 2012).
Maine	Maine's <i>Coastal Sand Dune Rules</i> require that structures greater than 2,500 square feet be set back at a distance that is calculated based on the future shoreline position and considering 0.6 meters (m) (or 2 feet [ft]) of sea level rise over the next 100 years (MDEP 2012).
Maryland	Maryland legislators passed the <i>Living Shorelines Act</i> to reduce hardened shorelines throughout the state. The State government also created the "Building Resilience to Climate Change" policy, which establishes practices and procedures related to facility siting and design, new land investments, habitat restoration, government operations, research and monitoring, resource planning, and advocacy. ³¹
Montana	Montana maintains a statewide climate change Web site to help stakeholders access

²⁸ See www.climatechange.alaska.gov/docs/iaw_accimp_27aug08.pdf.

²⁹ See <http://www.climatechange.ca.gov/adaptation/water.html>.

³⁰ See <http://scholarship.law.wm.edu/cgi/viewcontent.cgi?article=1003&context=wmelpr>.

³¹ See <http://www.cakex.org/case-studies/2829>.

	relevant and timely climate information, tools, and resources (Bierbaum et al. 2013).
New Mexico	New Mexico's Active Water Resource Management program allows for temporary water rights changes in real time in case of drought (Propst 2012).
Pennsylvania	The state government established policies to encourage the use of green infrastructure and ecosystem-based approaches for managing stormwater and flooding (Solecki et al. 2012).
Rhode Island	Rhode Island requires that public agencies considering land-use applications accommodate a 0.9–1.5-m (3–5-ft) rate of sea level rise (Bierbaum et al. 2013).
Texas	Texas coordinated the response to the 2011 drought through the NIDIS, RISAs (Southern Climate Impacts Planning Program and the Climate Assessment for the Southwest), and state and private-sector partners based on previously completed anticipatory planning and preparedness efforts (SCIPP 2010).
North Carolina	In partnership with CDC's Climate-Ready States and Cities Initiative, North Carolina has mapped storm surge predictions against the location of critical infrastructure of public health significance. Using inundation estimates at 0.5, 1, and 2 m (1.6, 3.3, and 6.6 ft) the health department has been able to determine vulnerable drinking water sources and drinking and wastewater treatment facilities that would be adversely affected and has begun planning to mitigate these risks. ³²
Massachusetts	In Massachusetts, each school district has a designated school that acts as an evacuation site in the event of an emergency. After identifying a need for infrastructure to protect vulnerable citizens during a heat event, the Massachusetts Health Department—in partnership with CDC's Climate-Ready States and Cities Initiative—is working with the state's Department of Education to secure funds to install air conditioning in these schools so they can be used as cooling shelters during extreme heat events. ³³

TABLE 6-2: EXAMPLES OF REGIONAL AND LOCAL ADAPTATION ACTIVITIES

Local or Regional Government	Adaptation Action
Satellite Beach, FL	Collaboration with the Indian River Lagoon National Estuary Program led to the incorporation of sea level rise projections and policies into the city's comprehensive growth management plan (Gregg et al. 2011).

³² North Carolina Department of Health and Human Services. Occupational and Environmental Epidemiology: Climate and Health. See <http://epi.publichealth.nc.gov/oeep/programs/climate.html>.

³³ Massachusetts Health and Human Services. Climate Change. See <http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/exposure-topics/public-health-implications-of-climate-change.html>.

Portland, OR	Portland updated its city code to require on-site stormwater management for new development and redevelopment and provides a downspout disconnection program to help promote on-site stormwater management. ³⁴
Lewes, DE	In partnership with Delaware Sea Grant, ICLEI-Local Governments for Sustainability, the University of Delaware, and state and regional partners, the City of Lewes undertook a stakeholder-driven process to understand how climate adaptation could be integrated into its hazard mitigation planning process. Recommendations for integration and operational changes were adopted by the City Council and are currently being implemented (Lewes 2011).
Groton, CT	Groton partnered with federal, state, regional, local, nongovernmental, and academic partners through EPA's Climate Ready Estuaries program to assess vulnerability to and devise solutions for sea level rise (Stults and Pagach 2011).
San Diego Bay, CA	Five municipalities partnered with the Port of San Diego, the airport, and more than 30 organizations with direct interests in the future of San Diego Bay to develop the San Diego Bay Sea Level Rise Adaptation Strategy. The strategy identified key vulnerabilities for the bay and adaptation actions that can be taken by individual agencies, as well as through regional collaboration (Solecki et al. 2012).
Chicago, IL	Through a number of development projects, the city has added 55 acres of permeable surfaces since 2008 and has more than four million square feet of green roofs planned or completed (Bierbaum et al. 2013).
King County, WA	King County created the King County Flood Control District in 2007 to address increased impacts from flooding through such activities as maintaining and repairing levees and revetments, acquiring repetitive loss properties, and improving countywide flood warnings (Bierbaum et al. 2013).
New York City, NY	Through a partnership with FEMA, the city has updated FEMA Flood Insurance Rate Maps based on more precise elevation data. The new maps will help stakeholders better understand their current and future flood risks and allow the city to more effectively plan for climate change (NPCC2 2013). In partnership with CDC's Climate-Ready States and Cities Initiative, New York City also used climate models to develop a more sensitive and customized heat-warning system to better protect New Yorkers during heat waves. This was achieved by studying retrospective hospitalization and mortality data, projections for relevant climate conditions (such as temperature and humidity), and localized modeling of the urban heat island effect (NPCC2 2010).
Southeast Florida Regional Climate Compact	Broward, Miami-Dade, Palm Beach, and Monroe counties have jointly committed to partner in reducing greenhouse gas emissions and adapting to climate impacts. ³⁵ They have already made significant progress in regional planning to address sea level rise.
Phoenix, AZ;	Climate change impacts are being integrated into public health planning and

³⁴ See <http://www.cnt.org/repository/Portland.pdf>

³⁵ Southeast Florida Regional Climate Compact. See <http://southeastfloridaclimatecompact.org/pdf/compact.pdf>.

Boston, MA; Philadelphia, PA; and New York, NY	implementation activities that include creating more community cooling centers, neighborhood watch programs, and reductions in the urban heat island effect (Vogel et al. 2011, Horton et al. 2011, White-Newsome et al. 2011).
Boulder, CO; New York, NY; and Seattle, WA	Water utilities in these communities are using climate information to assess vulnerability and inform decision making (Vogel and Smith 2010).
Philadelphia, PA	In 2006, the Philadelphia Water Department began a program to develop green stormwater infrastructure, intended to convert more than one-third of the city's impervious land cover to "Greened Acres," which include green facilities, green streets, green open spaces, green homes, and stream corridor restoration and preservation (Wilbanks et al. 2012b).

International Adaptation Activities

In September 2010, President Obama issued the Presidential Policy Directive on Global Development (PPD).³⁶ The PPD calls for the elevation of development as a core pillar of American foreign policy and addressing global climate change as a key development initiative. Adaptation to climate change is a central component and one of three important pillars of the PPD's Global Climate Change Initiative (GCCCI).³⁷

As part of the GCCCI, the United States is helping countries prepare for potentially severe climate change impacts (U.S. DOS 2012). For example, glacier retreat could have a devastating impact on water supply in Andean nations, India, Nepal, Bangladesh, Afghanistan, Pakistan, and Central Asia. The United States is building capacity for water resource management and supporting research on hydrological cycles, glacier dynamics, and adaption for downstream communities, as well as building climate resilience in Least Developed Countries (LDCs) and small-island developing states that are most vulnerable to extreme weather and other climate impacts. Support to the multilateral Pilot Program for Climate Resilience³⁸ has leveraged \$285 million in contributions from other developed country governments to help vulnerable developing countries, including several LDCs, pilot and demonstrate approaches for incorporating climate risk and resilience into development policies and planning.

The U.S. Agency for International Development (USAID) is investing in the scientific capacity of partner countries, and improving access to and use of climate information to help societies identify vulnerabilities and evaluate potential adaptation strategies (U.S. DOS 2012). The programs described below are examples of USAID's work to provide access to timely and user-driven information and to help communities adapt to climate variability and change.³⁹

- A collaborative effort between USAID and the NASA the SERVIR program⁴⁰ provides 10 countries in Central America and the Caribbean, 18 countries in East Africa, and 6 countries in the Hindu Kush-Himalaya region with satellite imagery and user-friendly weather and climate information, informing decision making in health, environmental management, disaster preparedness, and other areas. SERVIR supports national governments, universities, NGOs, and the private sector.

³⁶ Presidential Policy Directive on Global Development, September 2012. See http://foreignassistance.gov/Initiative_GCC_2012.aspx?FY=2012#ObjAnchor.

³⁷ President Obama's Development Policy and the Global Climate Change Initiative. See http://www.whitehouse.gov/sites/default/files/Climate_Fact_Sheet.pdf.

³⁸ Climate Investment Funds: Response to Call for Inputs from the Technology Executive Committee. See http://unfccc.int/ttclear/sunsetcms/storage/contents/stored-file-20130422151608983/CIF_EE.pdf.

³⁹ USAID, Global Climate Change Adaptation Activities. See <http://www.usaid.gov/what-we-do/environment-and-global-climate-change/global-climate-change-adaptation/global-climate-change-adaptation-activities>.

⁴⁰ SERVIR is a Spanish language acronym for Regional Visualization and Monitoring System.

- The Climate Services Partnership (CSP) was formed at the first International Conference on Climate Services in 2011 to improve understanding and application of climate services among decision makers and practitioners in developing countries. The CSP draws from a broad membership to promote the matching of the best information with those who need to use it in decision making. In doing so, the CSP supports the Global Framework for Climate Services, a formal international system that facilitates the coordinated support of climate services worldwide. The CSP is also building the capacity of national weather services to deliver climate information products to stakeholders in government ministries and the private sector.
- Created in 2010, the High Mountain Adaptation Partnership grew out of the Adaptation Partnership, which was founded by the United States, Spain, and Costa Rica to facilitate enhanced action on adaptation. It also built on a series of activities that USAID and the National Science Foundation organized in glacier-dependent areas. The program created a community of practice that brings together physical and social scientists, development practitioners, policy makers, and planners, with the aim of improving knowledge, fostering South–South information exchange, and mobilizing resources for applied research and multistakeholder-based adaptation projects in the Hindu Kush-Himalaya, Andes, Central Asia, and other high mountain regions. The program has pioneered new rapid assessment techniques for studying the risks of glacier lakes.
- Recognizing that women often possess skills that are relevant to adaptation, and are also disproportionately vulnerable to climate change impacts, USAID aims to make its adaptation efforts inclusive and gender sensitive and to demonstrate ways to effectively integrate this perspective into adaptation programs. For example, in Peru in 2010, USAID supported The Mountain Institute in conducting a series of community workshops to analyze climate vulnerability and test ways to integrate a gender approach into adaptation. Women identified the need to conserve local ecosystems like high Andean wetlands and grasslands, which are critical for water regulation, especially in the context of the melting glaciers. The project also provided leadership and climate change adaptation training to women serving on municipal councils.

Also in support of international adaptation efforts, the U.S. Department of State focuses on development and implementation of effective international adaptation policies and programs and promotes the integration of adaptation considerations into diplomatic and development initiatives in sectors that will be impacted by climate change, such as agriculture, water, and disaster risk management.⁴¹

CONCLUSIONS

In the last several years, major progress has been made on adaptation planning and implementation across all levels of government in the United States, including a focus on research, assessments, and adaptation. At the national level, the most recent Third NCA Report is a major step forward in building both scientific understanding and important partnerships focused on reducing risk, and the new “sustained assessments” approach is explicitly designed to support adaptation decisions (Draft Third NCA Report, 2013). The Interagency Climate Change Adaptation Task Force, comprised of more than 20 agencies and led by the Executive Office of the President, has produced a large number of adaptation initiatives and overseen the development of agency adaptation and sustainability plans for every federal agency.

Some states, including California, have made dramatic steps forward in increasing energy efficiency, reducing emissions, and increasing preparedness. Many other states have joined regional efforts to curb emissions. New York, Philadelphia, Chicago, San Francisco, and many smaller cities and towns have made impressive strides in reducing their vulnerability to climate-related impacts. In addition, tribes in Alaska and the Pacific Northwest and elsewhere have engaged in

⁴¹ U.S. Department of State, Global Climate Change. See <http://www.state.gov/e/oes/climate/>.

comprehensive climate change adaptation planning. At the same time, U.S. investments in support of adaptation efforts internationally have substantially expanded, in support of reducing risk in many developing countries.

Although much more work needs to be done both domestically and internationally, major progress has been made since the 2010 CAR. The most dramatic evidence to date of the U.S. commitment to managing emissions, increasing preparedness, and providing leadership in the international arena can be found in the June 2013 *President's Climate Action Plan* (EOP 2013).

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